

COMPETITIVE IMPLICATIONS OF ENVIRONMENTAL REGULATION IN THE PAINT AND COATINGS INDUSTRY

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THE PAINT AND COATINGS INDUSTRY

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EXECUTIVE SUMMARY

Introduction

During the late 1980s and early 1990s, industrial users of paint often faced strict environmental regulation on their operations because of the large volumes of solvents released in the surface coating process. These manufacturers turned to their paint suppliers demanding products which not only performed acceptably in all traditional characteristics but also incorporated significantly reduced amounts of organic solvents. U.S. paint manufacturers' need in the 1980s and 1990s to provide innovative solutions offers an example of how suppliers can be affected by regulations aimed at their customers. As regulations were promulgated, industry managers were forced to choose appropriate areas to dedicate development resources. Factors influencing these decisions included expected development time and costs, resource availability of the innovating firms, and anticipated market size for innovative products. Where the paint companies successfully developed compliant coatings, their customers were provided with opportunities for compliance at dramatically lower cost than would have been incurred in adopting control equipment solutions. Where paint manufacturers possessed technologies which were less environmentally damaging, the regulations spurred experimentation by their customers and in some cases allowed entry into markets where the suppliers had previously not participated.

Market Overview

Worldwide production of paints and coatings was estimated to be \$35 billion in 1990 with North American firms manufacturing almost 40% of this total. The market comprised three types of coatings: those sold to contractors and homeowners for interior and exterior wall covering, those sold to industrial manufacturers for product coatings, and those sold for special purpose applications. The first segment, known as architectural coatings was the largest making up 38% of the market. Original equipment manufacture (OEM) product coatings made up 32% of the 1990 U.S. market, and special purpose coatings made up 21% .¹ Special purpose paints were on items outside of a manufacturing site and for industrial purposes. Autobody refinishes made up almost half of this segment.

1. The U.S. Department of Commerce categorized an additional \$910 million market in its measurement of "Paints and Allied Products." Making up 7.3% of the total, allied products included dopes, thinners, pigment dispersions, and other similar products.

Three types of firms produced paints. The largest suppliers such as PPG Industries, Sherwin Williams, and ICI-Glidden provided coatings to several areas of the market. These firms dedicated large resources to maintain strong positions in large market segments. Often, they had integrated upstream to independently produce resins for their formulations or they had integrated downstream to market their products directly to customers through company owned stores.

A second type of firm provided specialized coatings to narrow segments of the OEM or special purpose markets. Suppliers to the largest market segments (BASF in automotive manufacturing and refinishing for example) ranked among the largest paint firms. Those which concentrated on smaller segments such as marine coatings or wood furniture manufacturing sometimes dominated in their markets, but typically ranked as only mid-sized suppliers.

A third type of firm focused only on architectural coatings. Although major paint companies including Duron and Benjamin Moore had achieved large industry positions producing primarily architectural coatings, hundreds of small firms also supplied this segment; most with revenues of less than \$5 million.

Environmental Regulations

Paints were applied to protect and enhance the appearance of a surface. Solvents in the coating facilitated application and assured a smooth finish, but were not part of the final coating. Eventually, all of the solvent evaporated from the coating and was either captured and controlled or was released as air emissions. In 1985, surface coating operations accounted for 27 % of all industrial emissions of volatile organic compounds (VOCs). When exposed to sunlight, these VOCs contributed to the formation of tropospheric (lower atmosphere) ozone. Regulations aimed at reducing tropospheric ozone levels targeted precursors including VOCs.

With the passage of several state regulations in the 1960s and 1970s as well as the Clean Air Act Amendments of 1977, users of industrial coatings began to be regulated in the United States. In accordance with the Clean Air Act Amendments of 1977, the EPA provided Control Technique Guidelines (CTG) and New Source Performance Standards (NSPS) as aids for the state regulators and

permit writers. These documents focused on individual types of manufacturers and provided guidance in methods of reducing emissions for their industry. Typically, they offered practical limits on the VOC content of coatings. Alternatively, manufacturers who chose not to change coatings could comply by adding control equipment to their operations.

While the U.S. led other industrial countries in the regulation of coating application, Germany, the Netherlands, and the U.K. began adopting similar regulations in the late 1980s. As in the U.S., these regulations focused on OEM operations. While these regulations had an important effect on several industries in Europe, the U.S. regulations remained the most strict.

In the OEM segment, competition in the paint market had always been based on the manufacturers' ability to provide a coating which satisfied the variety of customer performance requirements. Environmental regulation defined a new type of performance need - lower solvent content. As a result, the goal of reducing VOC emissions by reducing solvent became the primary focus of research and development in the U.S. paint industry throughout the 1980s and early 1990s. Paint suppliers hoped to provide formulations which employed lower amounts of solvent and thus could be used without control equipment. Therefore, without being directly regulated themselves, paint suppliers were dramatically affected by the regulations. As suppliers working under existing competitive systems, the paint companies had strong incentives to provide low cost solutions to their clients' regulatory requirements.

By 1991, the annual EPA survey of sources of VOC emissions demonstrated that paint regulations had had an impact. In that year, 1.86 million metric tons of VOCs were emitted by industrial surface coating operations. This represented a 15 % reduction from the 2.2 million metric tons emitted in 1986. During the same period, other industrial sources of VOC emissions increased by 5 % .

Industry Performance at the Time of Regulation

U.S. paint manufacturing showed modest sales increases in the late 1980s with compound annual growth of approximately 4% between 1986 and 1991 (22% overall growth during the same period VOC emissions fell 15 %). In 1991, the Department of Commerce reported that the value of shipments had

reached \$12.9 billion. Also during the late 1980s, the U.S. share of world exports held firm at approximately 9 % and the balance of trade grew substantially from \$150 million to \$320 million.

Effect of Regulation on Competitiveness

The influence of environmental regulations on the international competitiveness of the U.S. paint firms was modest in the early 1990s. At that time new regulations were just beginning to take effect in a few European countries and no regulations existed in Japan for coating processes. However, it can be seen that the U.S. position in world trade in paints remained strong even as manufacturers were compelled to dedicate increasing resources to low VOC developments. These developments were likely to find increasing international markets as regulation took effect in other countries.

In at least one case, the more stringent environmental regulations in the U.S. were a factor in encouraging the transfer of technology from Europe to the U.S. market. The manufacturer, having dedicated more than a decade of research efforts to water-borne automobile coatings, possessed a technology which was judged to be superior by several North American auto manufacturers as they explored their options under new regulations. The coating manufacturer entered a licensing arrangement with existing suppliers to access these customers. As regulations began to focus on automobile refinishes, the supplier was preparing to enter the market independently.

Within the U.S., the industry's response to regulations on different segments of the market is instructive on how supplying industries react to pending regulation. When California regulated wood furniture manufacturers, the relatively small coatings suppliers were unable to dedicate large resources to the demands of a regional part of their markets. Facing few alternatives to adopting expensive control equipment (in addition to high wage rates and other regulations), many manufacturers left the region. In time, and facing regulations on wood furniture manufacturers across the U.S., coatings suppliers were able to develop acceptable water-borne systems. Similarly, when the large automobile coatings market faced regulation suppliers rapidly developed alternative products.

Regulations on architectural coatings drove results which demonstrate the differing responses of suppliers depending on their resource availability. When architectural coatings were regulated in California, many small suppliers fought bitterly against the concept of reduced VOC requirements. Meanwhile, large producers (even in other parts of the country) anticipating a huge developing market opportunity dedicated large resources to innovative products which could be used with less adverse impact on the environment.

The characteristics of innovations in the paint industry have implications for any other regulated area. Here, as in many other areas, the innovations have not occurred within the regulated industry itself. Instead, new approaches were developed by suppliers at least one step up the value chain. In the case of new resin systems, the new developments were several steps upstream. These upstream industries must choose how to dedicate scarce resources. They will dedicate these resources to methods of lower cost environmental compliance when the regulations are structured to allow creative methods, the market for innovations is large relative to the required development investment, firms possess the needed resources, and the decision makers in the regulated area are receptive to new approaches of achieving compliance.

INDUSTRY STRUCTURE

Product

Product Description

The earliest development of the paint industry in the U.S. began with the first needs for coating and protecting residences. Paint companies were primarily pigment manufacturers who prepared powders of coloring by grinding naturally occurring materials. Until the middle of the nineteenth century, professional painters would combine pigments with an oil or varnish and thinners. In 1867, D.R. Averill prepared the first generation of ready mix paints. These emulsions of pigments in oil, zinc oxide, lead acetate, and lime water were initially found to be unacceptable by many painters. However, they set the stage for later developments by other manufacturers which increased the consistency and the quality of the product.² These developments dramatically changed the market for paints. Consistency began to depend on the manufacturer and not the skills of the journeyman painter. Also, the door was opened to less sophisticated buyers performing do-it-yourself activities on their homes.

The large market for coatings of rail cars and early automobiles spurred the initial growth in original equipment manufacturer (OEM) markets. Manufacturers began searching for innovative resins which could provide coatings which were more durable, faster drying, or less costly. Early substitutions for resins included coumarone, pheno-formaldehyde, and nitrocellulose. Concurrently, new solvents derived from coal and petroleum processes were being utilized. In the period following World War II, the technical sophistication of manufacturing paint increased substantially. As a result, the proliferation of small start up paint companies had decreased dramatically. From that time forward, the paint industry experienced a continuing consolidation.

The paint and coatings market was a large diverse industry in the early 1990s with a wide variety of applications and customers. OEM paint markets naturally followed the growth and decline of their manufacturing customers. Similarly, markets for architectural coatings were closely tied to construction activity. Not surprisingly then, the market for paints and coatings has been closely tied to the movements

² Sherwin Williams, Annual Report 1991, "125th Anniversary 1866-1991"

of the economy as a whole. Within the market, share shifts from low solids to high solids and water-borne coatings were the most notable developments in the early 1990s. Systems requiring no solvents, radiation cured and powder coatings, were also showing growth significantly greater than the rest of the market.

Once applied, paints and coatings formed thin continuous layers used to protect and decorate surfaces. As supplied to the user, paint and coatings were primarily made up of three components: resin, pigments, and solvents. After application and drying, only the resin and pigment systems remained in the paint as the solvent evaporated. The resin was a polymer material which made up the primary substance of the coating and provided its protective properties. Several polymers were employed by paint manufacturers for resin systems including alkyds, urethanes, acrylics, and polyesters. Pigments were carried in the resin to offer decorative features and in some cases assist in protecting the substrate from UV degradation. Inorganic materials such as titanium dioxide and aromatic organic materials including phthalocyanines were examples of widely used pigments.

Solvents were used in paints solely to facilitate application of the resin and pigment system to the substrate. Originally mixed into a powdered resin/pigment system at the site of application, the solvent most commonly used in the late nineteenth century was turpentine. Fossil fuel distillates began to be utilized as their availability became more widespread in the early 1900s, and following developments in the last half of the twentieth century, there was a progression toward greater use of water. By 1990, in most applications, solvents constituted 10% to 50% of the coating system; however in a few areas such as wood furniture coatings, solvents could make up 75% of the system.

Application of paints demanded a tradeoff. High solvent content could yield low viscosity and allow rapid application. However, this could also lead to dripping and running. With lower solvent content, the paint was not only more difficult to apply but it might not provide an acceptably smooth finish. As a result, paint formulators typically used several solvents. The use of water as the primary solvent, for example, did not necessarily mean that some petroleum derived solvents were not employed as well.

Substitutes

Because the paint and coatings industry was defined to include almost all types of chemical surface coverings, there were few substitutes for the products of this industry. Significant trends toward greater use of wallpaper or pre-treated paneling could have had a measurable effect on the architectural coatings market, but dramatic changes in consumer preferences in these areas were unusual. Similarly, for OEM (original equipment manufacturer) coatings, a dramatic shift in styles toward materials which did not require coatings would be required to significantly affect the size of this industry. Had, for example, the DeLorean automobile with its stainless steel body panels initiated a national trend, the \$970 million market for automobile coatings might have been threatened.

Production Process

Paint manufacturers were primarily formulators. They determined the combination of raw materials which satisfied the user's coating needs and supplied that formulation to their customers. The manufacturing process was a series of steps aimed at providing a uniform mix and sizing of component materials. There were five primary steps in this process. A premixing step where pigments, resins, and some solvents were combined, produced a paste of homogeneous composition. The pigment particle size was then reduced in a dispersion process. The next two steps involved thinning the material with additional solvents and then filtering the resulting product. Finally, the paint was packaged for delivery to customers³.

As a rule, only the largest paint firms performed significant levels of research and development. These development efforts involved formulating combinations of proprietary and commercial resins, solvents, pigments, and additives and performance testing. In the most concentrated markets such as automobile or appliance coatings, the manufacturers worked closely with the customer to develop a coating which provided a customized combination of performance characteristics.

3. Randall, Paul M "Pollution Prevention Methods in the Surface Coating Industry, " *Journal of Hazardous Materials*, Elsevier Science Publishers B. V. I Amsterdam, p. 282

Smaller firms relied on raw material manufacturers to provide formulation assistance. Lacking the resources to dedicate to basic research and development, these firms followed very closely the recommendations of their suppliers concerning constituent combinations.

Economies of Scale

Scale economies were modest in paint production because fixed costs which could be reduced by increasing volume were limited. Notably, spreading of research and development costs (4-6% of revenue for most large producers in the U.S.) and advertising costs (approximately 1% of architectural coatings sales in the U.S.) provided an advantage to larger firms. In operations, increasing batch size had the expected advantages in reducing average manufacturing costs. However, large manufacturers had limited advantage over regional producers in this area because the cost of distribution quickly overtook the advantage of increasing batch size. All of the largest manufacturers had adopted strategies of regional manufacturing to limit distribution costs.

Despite the limited economies of scale, the paint and coatings industry was consolidating (in terms of establishments) in both the United States and in Europe. In 1980, it is estimated that there were more than 1800 firms manufacturing paint in Europe. By 1990, that number had fallen to 1500 (an annual decline of more than 2%).⁴ In the United States, consolidation was also occurring. With a reduction of almost 1% annually, the number of firms producing paint in the United States declined from 1600 in 1977 to 1400 in 1992.⁵

Entry or Exit Barriers

Two significant barriers existed for new suppliers attempting to gain a position in these markets. The first barrier, particularly important in OEM markets, was the need for relationships with buyers which allowed joint development of new products. Buyers had highly specialized requirements which demanded

4. Information Research Limited. "A Profile of the West European Paint Industry, Ninth Edition," London, 1990

5. Rauch Associates, Inc. "The Rauch Guide to the U.S. Paint Industry," Bridgewater, N.J., 1990

that manufacturers dedicate significant technical resources to match coating characteristics to application needs. Often, the coatings were formulated for specific products produced by individual manufacturers. Smaller companies lacked the access to large OEMs and therefore could not anticipate their developing needs. The second barrier for entering large OEM markets was the requirement of coordinated development with manufacturers of application equipment. Product development required familiarity with the systems as well as access to advance information on innovations occurring in application technology. Coordinated development ultimately emerged where large buyers drove cooperative research between the dominant coatings suppliers and the major providers of application equipment. For example, in 1989, Union Carbide developed the Unicarb system, an innovative method of paint application for industrial uses (discussed further in a later section). Bringing the product to market required coordinated development with Nordson, a spray equipment manufacturer as well as with coatings suppliers such as Akzo, BASF, Gaurdsman, Lilly and PPG Industries.⁶

Buyers

Buyer Description

Customers required coatings to provide protection and enhance appearance. Additionally, depending on the surface to be coated, customers made selections based on price, ease of application, abrasion resistance, weather resistance, smoothness of finish, and non-toxicity. After the mid-1970s, customers also demanded that products comply with a variety of local, state, and national regulations requiring that coatings not exceed specified levels of volatile organic compounds (VOCs).

In a sense, the coatings market could be characterized as a continuum with one end occupied by the fragmented, poorly informed buyers undertaking infrequent home improvements. Many suppliers with products of varying quality supplied this end of the market; mass marketing skills and strong distribution channels represented strategic assets. On the other end of the continuum, market segments were dominated by a few highly informed buyers of coatings for original equipment manufacturers. Technical

6. "Supercritical CO₂ As a Solvent: Update on Union Carbide's Process." *Modern Paint and Coatings*, June, 1990

abilities to match product performance to narrowly defined customer needs and direct selling skills were required for success in these markets.

Distribution Channels

In the United States, architectural coatings made up 38% of the total 1990 market (table 7). Large firms successfully supplying this segment possessed strong commercial distribution systems. The three primary channels of distribution were:

- * Company owned stores
- * Distribution contracts with large mass merchandisers
- * Lumber and specialty retail stores

Additionally in the 1980s, the rapid development of large home improvement centers such as Home Depot had presented an additional growing channel to the “do it yourself” part of the market.

A number of large companies such as Sherwin-Williams operated company owned stores in order to control product presentation and achieve additional trademark recognition through buyer familiarity with the store and its signage. Smaller firms such as Dunn Edwards and Duron had achieved similar advantages on a regional level. Other firms though, such as PPG with its Lucite and Olympic paints, developed strong brand recognition while selling through national retailers.

Direct sales and specialized services were used in selling to the OEM market because there were only a few very knowledgeable buyers. Because a small number of people had control over very large - purchase decisions, the paint companies devoted significant resources to keeping these individuals informed of technological and performance developments.

Suppliers

The primary suppliers to the paint and coatings industry were producers of synthetic chemicals who manufactured resins, solvents, and pigments, usually from coal and petroleum feedstocks. International

firms such as Rohm & Haas, Reichhold Chemical, Dow Chemical, and Union Carbide Chemicals and Plastics Co. were important suppliers to the industry throughout the world.

Many of the largest U.S. suppliers of coatings including PPG, Sherwin Williams, and Lilly Industries had integrated upstream into manufacturing proprietary resins. Their innovations in basic resin chemistry had provided them with strategic advantages in several market segments. PPG's development of electrodeposition coatings for automotive underbodies in the 1970s and Glidden's developments in latex paints in the late 1940s were examples of innovations in resin chemistry which had allowed a firm to establish a dominant position in a market segment which lasted for decades.

Environmental Regulation

Environmental risk analysis

Three types of regulations affected the U.S. paint industry:

- * Production regulations required paint manufacturers to track their emissions more closely, invest in control equipment, and explore opportunities for waste minimization.
- * Site restoration regulations involved the identification and clean-up of previously disposed waste. Although this type of regulation was not unique to the U.S., the Superfund requirements were the most far reaching.
- * Users of paints and coatings were regulated to limit the emissions resulting from application processes. In many instances, the most cost effective means of remaining in compliance was to adopt coatings with lower solvent content. Paint manufacturers were, then, indirectly affected as their customers pressured them to provide compliant coatings.

As much as 70% of some coatings were made up of organic solvents. Therefore, the paint industry and its customers maintained important use and disposal responsibilities. Limitation of emissions was desired because of the role solvents played in the formation of low level ozone. In the troposphere (lower

atmosphere), the formation of ozone was undesirable because it was thought to cause adverse health effects and harm vegetation.⁷

The solvents were volatile organic compounds (VOCs) which were precursors to the formation of ozone. In the presence of sunlight, VOCs reacted with nitric oxide (NO) resulting in increased levels of nitrogen dioxide (NO₂). Since the ratio of NO to NO₂ was in equilibrium with the formation of ozone, the increased level of NO₂ led to increased levels of ozone.⁸ Regulations aimed at reductions of tropospheric ozone were focused on reducing emissions of the precursors.

In 1991 35% of all VOC emissions were thought to result from mobile sources, primarily automobiles. The remaining 65% occurred at stationary sources and were associated with solvent use, hazardous waste disposal, surface coating, petroleum marketing, petroleum refining, and chemical manufacturing. Surface coating contributed 11% of all VOC emissions.⁹ As a result, paint users were targeted for emission reductions in a series of air regulations

1991 U.S. National VOC
Release Estimates

Source	Releases (million ton)	Share
Industrial Releases (excluding coatings)	6.0	35%
Transportation Sources	5.1	30%
Surface Coatings	1.9	11%
Forest Fires and other burning	1.0	6%
Solid Waste Disposal	0.7	4%
Fuel Combustion	0.7	4%
Miscellaneous Organic Solvent Use	1.6	9%

Source: U.S. EPA
Figure 1

Severity and Impact of Regulations

In the U.S., paint manufacturers claimed that the cost of compliance with site restoration regulations was unnecessarily high. Following a survey of its members, the National Paints and Coatings Association

7. Reducing the formation of ozone in the troposphere should not be confused with efforts to stem destruction of the ozone layer in the stratosphere (where ozone protects the earth from harmful ultraviolet radiation).

8. U.S. Environmental Protection Agency, "Control Techniques for Volatile Organic Compound Emissions from Stationary Sources, Third Edition," 1986, p. 2-4 through 2-6

9. U.S. Environmental Protection Agency, "National Air Pollutant Emission Estimates, 1900 - 1991." October 1992

concluded that its members were spending \$7 million a month on Superfund negotiations in 1992.¹⁰ Strikingly, the organization concluded that of \$600 million spent prior to the survey, \$400 million had been spent on transaction costs (litigation and administrative fees). Only \$200 million had actually been spent on cleaning up sites.¹¹ While these costs represent less than 1% of annual revenue for the industry, they were not evenly spread across manufacturers. The survey found that 33 % of respondents were not affected by any Superfund clean-ups, and an additional 26% were involved at only one site. The costs incurred on different sites varied dramatically with \$50,000 to \$150,000 typically being required for a paint manufacturers experience on a single site (where they were often small contributors to the total volume of waste disposed)¹²

The operating cost of compliance with production regulations was modest. In 1989, U.S. paint manufacturers had capital expenditures for pollution abatement equipment of \$9 million while total capital expenditures were \$271 million (thus total capital expenditures were less than 2% of sales for the year and capital expenditures for environmental controls were 3 % of that).¹³

Pollution abatement operating costs were higher, but still represented only a small part of the overall cost of paint production. In 1990, U.S. paint and coating suppliers incurred \$91 million in pollution abatement operating costs with \$43 million of this going for the disposal of hazardous wastes. The total operating costs for pollution abatement represented approximately 0.7% of the value of shipments for 1990.¹⁴

10. Superfund refers to the Comprehensive Environmental Response Compensation and Liability Act. Passed in 1980, this legislation required that manufacturers fund remediation of sites in which they had disposed materials,

11. National Paint & Coatings Association, "Improving the Superfund: Correcting a National Public Policy Disaster," 1992

12. National Paint & Coatings Association, "improving the Super-fund: Correcting a National Public Policy Disaster," 1992

13. U.S. Department of Commerce, "Manufacturers' Pollution Abatement Capital Expenditures," 1990

14 U.S. Department of Commerce, "Manufacturers' Pollution Abatement Capital Expenditures," 1990

From a strategic standpoint, production and remediation expenditures represented costs which needed to be controlled. In most cases, however, responsibility for these costs remained in the environmental affairs, government affairs, and legal departments of paint manufacturing firms. By comparison, the regulations on paint users put new demands on broad areas of the organization. The companies' customers were demanding fundamental changes in formulation of the product. As a result, the sales, research, production, and purchasing organizations were affected. The upper management of the firms were faced with decisions of resource allocation to determine how best to respond to this major change in the industry's markets. For these reasons, the regulations affecting the use of the product were the most important environmental issue affecting the paints and coatings industry in the 1990s. Figure 2 summarizes the implementation of regulations aimed at controlling VOC content in the leading paint supplying countries. The following sections discuss these regulations and the characteristics of competition in each of these nations.

Timeline of Important Regulatory and Environmental Events	
1754	First U S paint manufacturer. Davoe Raynolds. is founded
1867	D.R. Averil leads development of “ready-mix-paints”
1948	Glidden introduces water-borne housepaints
1966	California adopts Rule 66 regulating VOC content of paint
1977	U.S Clean Air Act Amendments require development of Control Technique Guidelines for industrial coating operations.
1986	TA Luft regulates industrial coating operations in Germany
1986	Dutch government adopts KWS2000 targeting 50% reduction of VOC emissions by 2000
1990	U.K. passes Environmental Protection Act requiring the development of Guidance Documents for permittees regulating coating operations
1990	U. S. Clean Air Act Amendments target VOC reductions in eleven previously unregulated industries as well as requiring the development of a National Rule on VOC content of architectural coatings.
1991	23 countries sign United Nations European Commission for Europe protocol targeting 30% VOC reduction by 2000

Figure 2

COMPETITION

United States

Competitiveness Overview

The 1990 worldwide coatings market was estimated at \$35 billion. The United States and Canada made up almost 40% of this total with an estimated market of \$13.5 billion. Western Europe and Japan followed with market sizes of \$11.5 billion and \$4.5 billion respectively.¹⁵ The U.S. Department of Commerce estimated the production of paint and allied products at \$12.8 billion in 1990, having grown from a value of \$10.2 billion in 1985 (an annual growth rate of 4.6%) (table 7).

Because there was only a modest scale economy in the manufacturing process for paint, and shipping costs could quickly overwhelm the value of the product if the material were to be transported over long distances, firms strategically located manufacturing facilities to optimize the trade-off between scale advantages and increased shipping costs. Even within the U.S., firms produced in multiple locations. For these reasons most countries also shipped very little paint internationally, and the volume which was exported was dominated by shipments to neighboring nations.

This also means that trade data could only be used to get a first indication of a nation's competitive position. However, those nations which had large shares of the world trade in paint along with positive trade balances appear to have been the home for innovation and development in this industry. In 1990, the U.S. had a 9.2 % share of world export of paints ranking behind West Germany at 24.6%) the Netherlands at 10.7%. and the U.K. at 10.1%. However, the U.S. had the second strongest balance of trade in paints in 1990 at \$3 18 million trailing behind only West Germany at over \$800 million (tables 1-3).

15. "In Paints and Coatings, Change is the Only Constant," Chemicalweek, October 31, 1990

Leading Firms

Manufacturers in the paint industry fell into three segments.

- * Diversified Suppliers
- * Application Specific Suppliers
- * Architectural Coating Suppliers

Diversified Suppliers

The largest producers, characterized in the U.S. by PPG and Sherwin Williams, manufactured coatings for a variety of end-use areas. These firms held large shares in many of these segments, but also participated in areas where their share was very small, often after having acquired firms focused on these areas. At times, these firms unified the strategic management of their acquisition, but manufacturing facilities and sales efforts often remained focused on narrow market segments. In the late 1980s and early 1990s, a few large firms began rationalizing their businesses by returning to more narrow market segments. For example, in 1993, Lilly Industries and ICI-Glidden reinforced areas where each firm possessed a strong position. ICI traded its liquid industrial coatings business (and cash) for Lilly's packaging coatings business, an area where ICI was a recognized world leader.¹⁶

U.S. Total Value of Shipments of Original Equipment Manufacturer Paint

Category	1990 Value (million)
Transportation Coatings:	
Automobile Finishes	\$967
Truck, Bus, and RV Finishes	\$199
Other Transportation Finishes (inc. aircraft and rail)	\$77
Container and Closure Finishes	\$487
Metal building Product Finishes	\$345
Wood Furniture	\$339
Nonwood Furniture and Fixture Finishes	\$251
Machinery and Equipment Finishes	\$200
Paper, etc. Finishes	\$89
Wood and Board Flat Stock Finishes	\$67
Appliance, Heating Equipment, and Air Conditioning	\$65
Electrical Insulating Coatings	\$28
Powder Coatings	\$244
Other Industrial Product Finishes	\$327

Source: U.S. Department of Commerce, Current Industrial Reports, Paint and Allied Products, 1991

Figure 3

16. The Glidden Company, "ICI Paints Agrees With Lilly Industries on Business Transfer," Company Press Release, March 2, 1993

Application Specific Suppliers

Many coatings firms focused exclusively on narrow segments of the OEM or special purpose market. Working closely with their customers, these firms developed technical expertise in balancing the various needs of these industrial manufacturers. Depending on the segment size, these manufacturers could rank among the largest in the industry. BASF and DuPont, for example, sold coatings primarily to automobile producers and refinishers. Achieving large shares in these markets made these firms among the largest coatings suppliers in the world. In other segments, even the leading suppliers were fairly small. With revenues below \$100 million, companies such as Ameron, or Guardsman were dwarfed by the largest coatings suppliers, but they held large market shares in specific segments such as aerospace coatings, or wood furniture finishing.

In the OEM coating segment, almost all sales were made directly to the customer through the producer's sales force. In addition to providing specific formulations for the customer's needs, paint suppliers provided a variety of services to their largest clients which could encompass all aspects of coating the customer's products. PPG, for example, assisted in incorporating its paints into customers' existing equipment, advised customers on other types of equipment to use, and in some cases, even managed the entire painting process on a contract basis.¹⁷

The most consolidated areas of the OEM market were automobile with three primary suppliers (PPG, BASF, and DuPont), can coating with two primary suppliers (ICI and Dexter), and wood furniture finishing with four primary suppliers (Lilly Industries, Gaurdsman, Valspar, and Akzo-Reliance). These segments made up 7.8 %, 3.9%, and 2.8 % of the total market for coatings, repectively .

During the 1990s, strong firms participated in foreign markets in ways other than direct export, primarily by purchasing existing assets from local owners. In OEM coatings, U.S. firms had followed their clients in their pursuit of global markets. As automobile, beverage can, and appliance manufacturing firms

17. PPG Industries, Inc., William V. Warnick - Director, C&R Manufacturing, Interview Pittsburgh, PA, February 25. 1993

located operations internationally, the coating companies serving those firms purchased local firms to maintain longstanding relationships. Technology was transferred to the local facilities from the U.S. and applied in existing equipment. PPG, for example, became one of the five largest paint suppliers in Europe through strategic acquisitions in Italy, Germany, Spain, France, and the U.K. A substantial share of this revenue resulted from sales of electrodeposition coatings for automobile underbodies, technology developed in the U.S. but later transferred throughout the world.

Architectural Coatings Suppliers

The third group of companies were those providing architectural coatings (interior and exterior housepaints) to a regional market. While a few of these firms provided paints to some OEM or specialty segments, they focused primarily on regional sales to trade and consumer buyers. Larger firms in the U.S. included Benjamin Moore (\$350 MM 1990 sales), Kelly Moore (\$175 MM), and Pratt & Lambert (\$140 MM) but hundreds of companies fit into this category with most having revenues of less than \$5 million. While a few of these firms were very strong on a regional level, they all faced significant competition from diversified national firms. As a result, the smaller producers competed in niche markets, by providing private label products to smaller retailers, and by pursuing continual cost reductions. The strength of the national market leaders was demonstrated by the positions of the two largest manufacturers of architectural coatings, Sherwin Williams and Glidden (ICI) with market shares of 15.9% and 13.2%. respectively.¹⁸

The largest producers of architectural coatings also manufactured products which they categorized as industrial maintenance coatings. These products had similar characteristics, but often had been modified to offer application specific properties. Coatings used for chemical manufacturing facilities, for example, needed to provide greater corrosion resistance and durability than standard house paints. Similarly, paints used for corrosion protection on bridges needed to have specialized protective qualities. Sales of industrial coatings were primarily made directly to those responsible for facility maintenance for whom cost was a significant consideration.

18. "Prospects Improve for a Mature U.S. Market," Chemicalweek, October 31, 1990)

Distinctive Environmental Regulation in the United States

California led the regulation of paint emissions with the adoption in Los Angeles County of Rule 66 in 1966. The developers of this rule had determined, through the use of 8-hour smog chamber tests, that hydrocarbons had differing levels of photochemical reactivity and categorized substances into three classes based on their tendency to produce ozone. All facilities were compelled to remain below allowable emission levels for each category. In order to stay within the limits of regulations, paint users were required to maintain production at a level which kept emissions within compliance, adapt control equipment to collect and destroy paint emissions, or begin to use paints using innovative solvent systems which were described as California compliant.¹⁹

The first federal initiatives aimed at reducing VOC emissions resulted from the passage of the Clean Air Act Amendments of 1977. As required in the legislation, standards were established for acceptable levels of ambient ozone. States were compelled to develop plans for reaching compliance in non-attainment areas. The areas most out of compliance and thus requiring the most strict new standards were the LA Basin, the northern New Jersey/New York City region, Houston, and Chicago.

The 1977 Amendments required that the EPA provide guidance to the states in developing their implementation plans through the development of Control Technique Guidelines (CTGs). In addition, the EPA was responsible for developing new source performance standards (NSPS). These were rules governing the characteristics of new facilities regardless of whether or not they were in a non-attainment area. Control Technique guidelines were based on reasonably available control technologies while the NSPS outlined the best demonstrated technology (CTGs were less strict than the NSPSs).

Control Technique Guidelines provided emission reduction options for selected industry segments. Among the first were CTGs for the following industries: cans, coils, paper, fabrics, automobiles, light duty trucks, metal furniture, insulation magnetic wire, large appliances, miscellaneous metal parts, graphic arts, and flat wood paneling. Many of the guidelines were framed around a concept of allowable

19. California Air Resources Board, Daryl Bums, Telephone interview March 10, 1993

VOC content of the coating. For example, the CTG for automotive coatings put limits of VOC content at 1.2 lb/gallon excluding water for prime coats, 2.8 lb/gallon excluding water for guide coat and top coat, and 4.8 lb/gallon excluding water for paints used in final repair.

As a base CTGs were aimed at establishing methods for facilities to achieve an emission level equivalent to using existing coatings with a control system capturing 90% of emissions and achieving a destruction rate (efficiency of the system in reducing the materials to carbon dioxide and water) of 90%. However, some easing of the regulations was permitted to encourage the adoption of substitute coatings rather than end-of-pipe treatments. Negotiations with industry were conducted to establish requirements which could be met by existing coatings. The guidelines were also structured to allow manufacturers to use control devices if coatings containing higher VOC levels were chosen for performance reasons.²⁰

Although efforts were made to target large, growing industries with high contributions to ozone levels, CTGs were not issued for several areas with substantial VOC emissions. Notably, no CTG was issued for automobile refinishing primarily because of the recognition of the difficulty of achieving acceptable enforcement on tens of thousands of facilities. Similarly, no CTG was issued for architectural coatings because of the difficulty in enforcing a use regulation on a consumer product. In wood furniture coatings, no cost effective technology existed to reduce the very high levels of VOC content.

The 1990 Clean Air Act Amendments required that the EPA provide an additional eleven CTGs to the states. The Agency was responsible for identifying nine of these. Two were specified, aerospace coatings and ship building and repair. Aerospace manufacturers actually lobbied to have a CTG developed specifically for their industry. Given the unique demands of coatings used on a fuselage, aerospace manufacturers had been concerned that their coatings would be regulated according to the CTG for miscellaneous metal products.

20. U.S. Environmental Protection Agency, James Berry - Section Chief and David Salman - Industrial Engineer. Interview January 19, 1993

The 1990 amendments required that regulation of architectural coatings be accomplished through the development of a national rule. As with CTGs the focus of the national rule was to be on allowable levels of VOCs. The EPA included industry opinions in the rule making process by adopting a regulatory negotiation (reg-neg) process. The EPA provided information to manufacturers through this process, and industry was allowed to provide comments and proposals to the reg-neg for VOC levels with which they felt they could comply. Additionally, manufacturers were invited to “have seats at the negotiating table” where they could voice their recommendations for the developing regulations.

Sources of Competitive Advantage

Factor Conditions

Basic factor conditions were not a critical source of competitive advantage to the paint industry in the 1990s. Unlike the case in the early 1900s, the importance of factor conditions decreased significantly in the paint industry over the second half of the twentieth century. Originally, the industry required a ready source of such naturally occurring raw materials as linseed oil and turpentine. The availability of these materials had been a major factor in the early establishment of the industry in Louisville, Kentucky and Cleveland, Ohio.²¹ However, developments in organic chemistry resulted in a move away from naturally occurring materials throughout the middle part of this century.

With a limited reliance on natural production factors, the critical input to the U.S. paint industry was the knowledge of a specialized labor pool. The development of the industry relied on the creativity of individuals focused on providing new types of coatings through developments in resin and solvent chemistry. Following the many developments in organic chemistry occurring during the World War II, the ultimate raw materials of many paints were petroleum and coal distillates which had been modified and polymerized to enhance desired properties. As a result, in the major centers of U.S. paint manufacturing, Cleveland, Louisville, and Chicago, industry associations worked closely with academic

21. Schulenberg, Fred, “America’s Great Coating Centers: Cleveland, Part I,” *American Paint and Coatings Journal*, January 5, 1987, and Schulenberg, Fred, “America’s Great Coatings Centers: Louisville, Part I,” *American Paint and Coatings Journal*, May 19, 1986

programs to develop strong programs in Polymer science and coating technology.²² Notably programs at Case Western Reserve University, the University of Akron, and Kent State University (all near Cleveland) as well as the University Of Louisville had built strong ties with industry and frequently worked with the industry in technical development.

Domestic Demand Conditions

It has been noted above that paint and coatings markets must be segmented to understand the underlying demand conditions. In the (1990) \$4.9 billion U.S. architectural coatings market, buyers tended to make purchases infrequently. These customers made purchase decisions based on price, convenience of the purchase site, brand familiarity and ease of use of the product (particularly those that chose water-borne products). As a result, suppliers to this part of the market focused on cost controls and productivity improvements. Additionally, many manufacturers developed extensive distribution systems with company owned or franchised stores. Customers would seek advice in these stores concerning application methods, clean up requirements, and color matching. In larger companies such as Sherwin Williams, information would then be fed back to research and development areas to satisfy emerging customer needs.

In the OEM market and the special purpose market, however, highly sophisticated buyers reviewed a large variety of candidate coatings before selecting one which provided the required combination of properties. Paint manufacturers that were able to satisfy these changing needs on a continuing basis grew (and at times declined) with the industries they supported. The geographic grouping of the paint industry in Cleveland and Chicago owed its development to traditional partnering of OEM manufacturers of automobiles, carriages, and farm equipment with their coatings suppliers.

OEM buyers were, of course, concerned about price, but performance characteristics and ease of application were often more important than simple cost per gallon comparisons. This attitude was driven by the importance of the coating in marketing the product, particularly as compared to the overall selling

22. Schulenberg, Fred, "America's Great Coatings Centers: Cleveland, Part IV." American Paints and Coatings Journal, March 30, 1987 and Schulenberg, Fred, "America's Great Coatings Centers: Louisville, Part III," American Paints and Coatings Journal. June 16. 1986

price. For example, the total coating cost of a grand piano selling for \$10,000 would be only approximately \$25. However, the appearance of the instrument would dramatically affect its appeal to customers. A similar comparison was often made concerning the coating costs of automobiles. In this industry, several manufacturers pointed out that the “paint sold the car. ”

Process characteristics were a major concern of OEM buyers. The ability to improve transfer efficiency or reduce coating time could quickly offset higher costs of materials. Sophisticated OEM buyers looked at the total cost of coating and then made comparisons of the expected impact on the product’s attractiveness to customers.

Because paint suppliers needed to be well informed on all aspects of the customers needs, strong relationships developed between the firms. Having made specialized developments, paint suppliers became aligned with particular segments of the market. Buyers would signal emerging needs and encourage new developments by the primary suppliers to the industry. In areas such as automobile and aerospace manufacturing, where the U.S. had led development at one time, coatings suppliers often led new developments later adopted by foreign manufacturers.

Related and Supporting Industries

The simplicity of paint manufacturing resulted in limited reliance on supporting industries for process equipment and services. However, modern paint companies depended on developments in polymer chemistry to provide innovative products to their customers. It is not surprising, then, that the strong positions of Germany, the Netherlands, and the United Kingdom identified above were supported by leading chemical industries. Although not leading, the U.S. chemical industry was strong in many areas and had particular success in polymer chemistry.

In each country with a competitive paint manufacturing industry, a cluster of industries supported by synthetic organic compound production was evident (see figure 1). These manufacturers provided the intermediary processes required to modify simple organic substances derived from naturally occurring sources (primarily coal and petroleum). Paint manufacturers developing new ways of satisfying buyers’

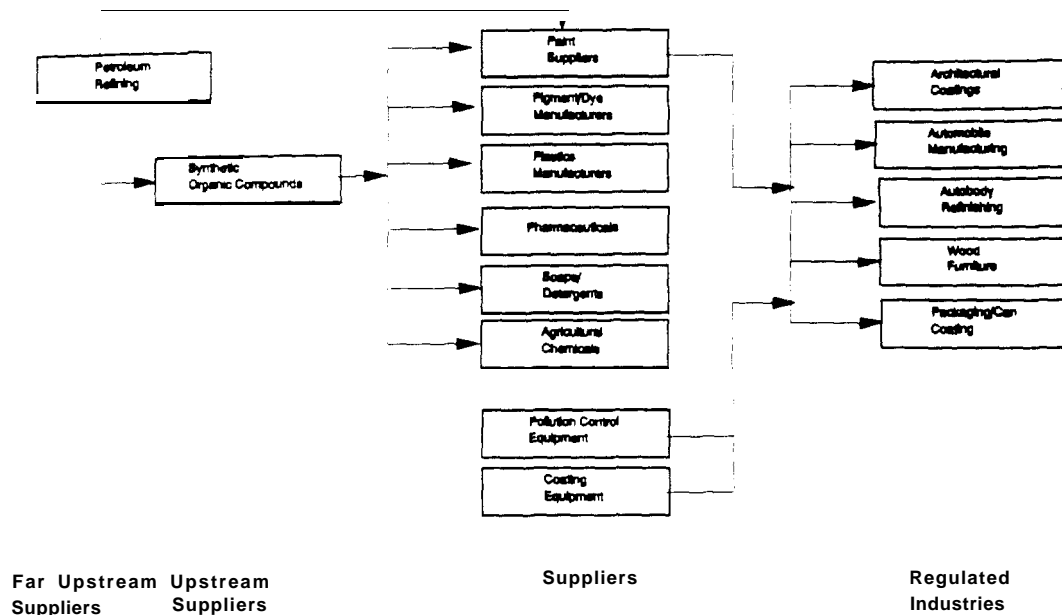


Figure 4: Industry cluster for paints and coatings manufacturing

demands relied on this industry to provide unique chemistries with previously unavailable combinations of properties. Typically, in countries where the synthetic organic compound industry was strong, other downstream industries besides paint were also strong. Other industries relying on innovative synthetic organic compound firms included plastics, pharmaceutical, soaps and detergents, and agricultural chemicals.

Strategy, Structure and Rivalry

In the U.S. the architectural coatings market was served by a large number of mostly small firms. In its early days the paint market was easy to enter, particularly in Chicago, Louisville, and Cleveland. The availability of raw materials, the relationship with customers, and the ready access to rail and canal distribution systems provide some explanation for why the coatings industry became important in these cities. Once the industry started, the low capital cost needed to enter the market encouraged many individuals to leave the firms where they received their training and begin their own operations. Firms

such as Peaslee-Gilbert (a strong early manufacturer and later a part of Devco Reynolds) and Sherwin Williams developed reputations as the training ground for later entrepreneurs. Many of the new firms were started within a few miles of the firm where the founder had learned the business.

The intense rivalries among the small entrepreneurial firms yielded continued improvements in the areas most important to customers. Improvements in customer service and product quality and performance resulted. While each of the major paint manufacturers recognized that investments in research and innovation were of primary importance, they adopted different strategies. Sherwin-Williams, for example, invested in process technologies, such as new methods of milling pigments. The company developed a system that ground pigments fine enough to remain in suspension in the oil. This ensured a high quality of ready-mix paint. The Glidden Company researched better substitutes for paint media and solvents which led to the first nitrocellulose lacquers and other quick drying finishes. Continued emphasis on new materials led the company to introduce the first water-borne latex household paint in 1948. Reliance Universal, Inc. was an early leader in emphasizing research into custom formulations and applications for specific customers. The company then supported its investments into this strategy by adopting decentralized production, locating its plants close to customers.²³

Germany

Competitiveness Overview

In 1990, West German paint production was approximately 12% of world total at \$4.3 billion. This demonstrated annual growth of approximately 4% from 1985 production of \$3.6 billion (no data was available for unified Germany).²⁴ In 1990, West Germany had a commanding position with 25 % of world exports of paints and the largest positive trade balance of any country, \$800 million (tables 1 and 3).

23. Schulenberg, Fred, "America's Great Coatings Centers: Louisville, Part II." American Paints and Coatings Journal, May 26, 1986

24. "Restructuring Continues in Europe," Chemicalweek, October 31, 1990

Leading Firms

The major suppliers of paint in Germany were chemical companies which had forward integrated in a movement reported to have begun with the acquisition of Glasurit Werke Winklemann by BASF in 1965. In 1990, following further acquisition, BASF led manufacturers in German paint production with an estimated 25% share.²⁵ Hoechst (through its subsidiary Herberts), the British firm, ICI and the Dutch firm, Akro followed, each estimated market shares of more than 5%.²⁶

In 1985, BASF completed the largest investment in the U.S. paint industry ever undertaken, Reportedly to expand its position in automobile OEM and repair finishes, the company purchased the coatings operations of Inmont for a price of \$1 billion. In 1992, the U.S. operations of the company had revenue of \$975 million (including sales of printing inks and dyes).

Distinctive Environmental Regulations

Concerns with tropospheric ozone and thus emissions of VOCs were receiving growing attention in Europe in the early 1990s. As seen in Table 11, the level of VOC emissions was fairly well correlated with a nation's production. As a result, the leading producer nations took the lead in implementing regulations on the sources of VOCs.

On November 19, 1991, 23 countries signed a United Nations European Commission for Europe (ECE) protocol for reduction of VOCs. The aim of the agreement was for each country to achieve a 30% reduction in emissions by 2000. The definition of the base year was left to the signatory countries so that those such as Denmark or Switzerland where many controls were already in place were not unfairly penalized for their prior efforts. Additionally, less industrialized countries, Hungary, Bulgaria, Ukraine,

25 Information Research Limited, "A Profile of the West European Paint Industry," London, 1990

26. Information Research Limited, "A Profile of the West European Paint Industry," London, 1990

and Greece which had comparatively low ambient VOC levels agreed to “standstill” emissions at 1987 levels.²⁷

Although the signing of the protocol was the first step leading to regulations on paint composition and use, individual nations were expected to develop their own plans for reaching VOC reduction goals. By 1992, implementation systems were already seen to vary and decisions concerning when to address paint emissions versus automobile, petroleum marketing, chemical manufacturing and other areas differed among the signatory countries. At that time, the countries which were closest to direct regulation of coatings application were Germany, the UK, and the Netherlands (see below for discussions of specific regulatory approaches in the UK and the Netherlands).

In Germany, efforts to improve air quality originated with the 1974 Bundesimmissionschutzverordnung (BIMSchV), or Federal Immission Control Act. As in the use of CTGs in the U.S. Clean Air Act, the German legislation required implementation of the program in the Lander (states) according to recommendations in the Technical Instructions on Air Quality Control (TA Luft). The TA Luft was amended and updated periodically including changes occurring in 1986 and 1991. Until 1991, the primary impact on the paint industry was a requirement to receive formal approval for plants using more than 250 kg/hour of solvents. Manufacturers emitting higher levels were required to demonstrate equivalent reductions at other facilities. The impact on the paint industry was modest.

The 1991 amendments to TA Luft increased the stringency of requirements in the use of coatings. Regulations on coating processes in automotive manufacturing, for example, put limits on emissions of 60 grams of organic solvent emissions in the waste gas of the overall facility per square meter of car body

27 Dutch Ministry of Housing Physical Planning and Environment, “The ECE Protocol on VOC Emissions Elucidated,” VOC Newsletter, February, 1992

surface covered.²⁸ As seen in table 12, this requirement was more strict than similar regulations in the U.K., but substantially higher than reported results of the best performing facilities in the U.S.

In other surface coating areas, the limits were based on allowable mass concentration of organic solvents in the waste gas (20 mg/m³ in spray booth areas, for example). Outside auditors using established guidelines performed yearly assessments to assure compliance. Switzerland, Austria, and Denmark traditionally used TA Luft as a model for their regulations, so similar rules on OEM coatings were anticipated to be implemented in these countries.

The Netherlands

Competitiveness Overview

Although the Netherlands only accounted for 3.9% of all world exports in 1990, the country was responsible for 11.0% of paint shipments (table 1). The Dutch balance of trade in the industry had risen from \$106 million in 1985 to \$268 million in 1990 (table 3). These values represented almost one third of the total production of the nation which was estimated in 1990 to be \$898 million.²⁹

Leading Firms

The Dutch paint industry was perhaps the most concentrated in all of Europe with Akzo controlling more than 40 % of the market followed by the Belgian owned Sigma Coatings with 25 %. Smaller shares were supplied by Herberts of Germany and Kemira Color of Finland.³⁰

In 1989, Akzo acquired Reliance Universal of the U.S. for \$275 million. The acquisition was driven by an expressed desire to enter the large steady market for U.S. coatings. Reliance Universal with \$320 million in revenue had been held for several years by the Tyler Company, a holding company with very

²⁸ The regulations go on to require "full use of the possibilities to further reduce the emissions by employing varnish systems which are poor in or free from solvents, highly effective coating procedures, air circulation procedures or by waste gas cleaning, particularly in the spraying areas."

²⁹ "Restructuring Continues in Europe," Chemicalweek, October 31, 1990

³⁰ information Research Limited, "A Profile of the West European Paint Industry," London, 1990

limited participation in the firm's operations. Tyler Company had acted as a white knight acquirer in a much earlier unfriendly takeover attempt of the firm.

Environmental Regulations

VOC reductions in the Netherlands were being targeted by a set of cooperative agreements established by KWS2000.³¹ Attempting to reduce emissions by 50% by 2000, partnerships which included industry, local government, and the federal government were formed to find solutions. Permit systems were to be used to monitor progress. The process was intended to be highly cooperative and extremely flexible in its ability to incorporate new information. In the following quote, representatives of Projectbureau KWS2000 described how the permit system was used to update facility performance once new information about technology was developed:

“In 1989, two projects were subsidized, demonstrating the use of water-borne and powder coatings for production of metal furniture. These projects were successful. Based on this, the Measure Group, supported by the Task Group Paint, set in a number of actions. First a list was compiled of all companies producing metal furniture. Second, the report was sent to these companies, and the corresponding authorities. The authorities were requested to take note of the content of these reports and to introduce the consequences into relevant permits. Third, the companies themselves were approached by an advisory institution, in order to inform the companies of this development, and to ascertain that they will indeed make the necessary arrangements. Lastly, the authorities will once again be approached some time in the future to find whether the measure has indeed been incorporated into the permits.”³²

31. KWS2000's name is derived from the abbreviation for the Dutch word *koolwaterstoffen* meaning hydrocarbon and the goal of 50% reduction in emissions by the year 2000.

32. Projectbureau KWS2000, personal communication from Waldo Kaiser and Dominic Shrijer, March 12, 1993

In 1992, this program had had only a limited impact on the paint industry. However, as industrial firms exhausted the most easily targeted areas for reduction, coatings operations were beginning to be examined for potential opportunities.

United Kingdom

Competitiveness Overview

The British paint industry was characterized by slow growth throughout the late 1980s. Production was estimated at \$2.0 billion in 1985 and had grown less than 1% annually to \$2.1 billion in 1990.³³ In 1990, the UK was responsible for 10.9% of world exports of paint as compared to a 5.5% share of all exports and the paint industry possessed a positive balance of trade of almost \$230 million (tables 1-3).

Leading Firms

ICI, based in the UK, was the world's largest manufacturer of paints and coatings. In 1990, the firm had a 20% share of its home market.³⁴ Scandinavian firms Crown-Berger (owned by Casco-Nobel of Sweden) and Macpherson (owned by Kemira of Finland) followed with estimated 12.5% and 9.5% shares. Britain's other internationally strong producer Courtaulds held an 8.5% share of the home market.³⁵

ICI and Courtaulds had developed strong U.S. positions through acquisitions. In 1986, ICI had purchased the Cleveland firm Glidden, at that time the third largest coatings company in the U.S. The acquisition was consistent with ICI's explicit strategy of globalization. ICI acquired Glidden for \$580 million, when the company had pre-tax profits of \$60 million on sales of \$650 million.³⁶

33. "Restructuring Continues in Europe," Chemicalweek, October 31, 1990

34. Information Research Limited, "A Profile of the West European Paint Industry," London, 1990

35. Information Research Limited, "A Profile of the West European Paint Industry," London, 1990

36. Imperial Chemical Industries PLC, "Major Acquisition Makes ICI World Paints Leader, Company Press Release, August 15, 1986

Courtaulds had also expanded its presence in the U.S. coatings market through acquisitions. In 1987, the company purchased Porter Paints of the U.S. for \$140 million gaining a strong position in the midwest and southwest of the U.S. for architectural coatings. Porter Paints had been a privately held family business with sales in 1987 of \$120 million.³⁷ Courtaulds' U.S. OEM and industrial coatings positions were further strengthened through the purchase of Products Research and Chemical for \$260 million in 1989 and Desoto Industrial Coatings for \$135 million in 1990.³⁸ As a result of these transactions, Courtaulds ranked among the ten largest suppliers of coatings in the U.S. in the early 1990s.

Environmental Regulations

In the UK, passage of the 1990 Environmental Protection Act was expected to put demands on reducing VOC emissions from coating operations. Again, the primary federal responsibility was to provide assistance to local regulators and permit writers in methods of achieving emissions reductions. Guidance documents stipulating VOC content in industrial coatings were provided by Her Majesty's Inspectorate of Pollution. These documents outlined the "best available technology not exceeding excessive cost" (BATNEEC) for reducing emissions in industrial processes outlined in the Environmental Protection Act. Guidance documents were issued in a wide variety of areas affecting paints and coatings operations including vehicle manufacturing, wood furniture coating, refinishing of automobiles, and many others. In fact, the Environmental Protection Act may have covered more areas of industry than the regulations in any other country. However, as can be seen in tables 12 and 13, compliance requirements under the British regulations were less strict than those found in the rules of other countries.

"Rest of World" Markets

Large coatings manufacturers had entered the rapidly growing markets of Southeast Asia and Latin America by building new facilities. In the early 1990s, architectural coatings sales here were reported

37. Courtaulds Coatings Inc., "Porter Paint Co. Acquired by Courtaulds," Company Press Release, October 26, 1987

38. U. S. Department of Commerce, "Foreign Direct Investment in the United States," 1990 Transactions

to have grown by more than 10% ,³⁹ making these regions significantly more attractive than home markets growing only at the rate of GDP. ICI, Sherwin Williams, Akzo, BASF, and Courtaulds had all made significant investments in these growing markets. Additionally, the two large Japanese manufacturers Nippon and Kansai had expanded markets into Southeast Asia. Although environmental regulations were limited in these markets, several manufacturers reported that production facilities in these areas were built to the most stringent environmental requirements of any of the geographies in which they had facilities.⁴⁰

39 "ICI Paints Chief Cites Growth in the New Hot Market: Asia," Chemical Week October 14, 1992

40 PPG Industries, Inc. Douglas B. Atkinson - Director Interview, February 25, 1993

EFFECTS OF REGULATION ON COMPETITIVE ADVANTAGE

Methods of Achieving Environmental Goals

As has been stated above, the first VOC paint regulations in the United States focused on the OEM segment of the market. Local rules, primarily in California, addressed manufacturers, but also put regulation on the content of architectural coatings. While compliance in architectural coatings was achieved almost exclusively through substitution of raw materials, manufacturing facilities have achieved lower VOC emissions in a variety of ways:

- * Substitution of new materials in the solvent/resin system
- * Development of coatings which did not require solvents
- * Adoption of application techniques with higher transfer efficiencies
- * Development of application devices which did not require solvents
- * Installation of control systems to capture and destroy or recover emissions

The following tables summarize how the adoption of these technologies affected the regulated groups and their suppliers. In cases where original equipment manufacturers were affected, the impending regulations were initially anticipated to drive substantial costs for abatement equipment. Many analyses of the impact of an environmental initiative stop at that point. However, as seen in these tables, projecting from the existing situation exclusively in the regulated industry overlooks the potential for innovation by that industry and, perhaps more importantly, by its suppliers.

The ability to offset the anticipated environmental costs for their customers led to strategic opportunities for a variety of coatings and equipment suppliers. Which firms benefited from these opportunities depended on their available resources, their ability to innovate, and the willingness of their customers to take risks in incorporating new technologies. Similar factors affected the opportunities in the market for architectural coatings; although here, regulators were potentially more influential in forcing customers to adopt new coatings.

Competitive Effects of Automobile Coatings Regulations on the Industry and Its Suppliers

Method	Automobile Paint Suppliers	Automobile Companies
High Solids Paint Systems	* Increased costs associated with development of new products	<ul style="list-style-type: none"> Expenditures for control equipment which reported to be as high as \$20-40 million in single facilities. Auto companies claimed environmental capital and operating costs of over \$40 per vehicle
		<ul style="list-style-type: none"> Diminished ability to achieve optimum surface finish
	* Share shift and licensing opportunities for innovative firms	
Waterborne Paint Systems	* Increased costs associated with development of new products	* Capital expenditures of approximately \$20 million per facility where sufficient space was available. Alternatively, similar additional costs for flash ovens in new paint lines
	* Share shift and licensing opportunities for innovative firms	Substantially improved appearance over high-solids paint systems
Powder or Radiation Cured Coatings Where Applicable		* Reduced coating costs through material savings

Competitive Effects of Wood Furniture Coatings Regulations on the Industry and Its Suppliers

Method	Equipment Suppliers	Coating Suppliers	Wood Furniture Companies
Adopt Control Technologies			<ul style="list-style-type: none"> Expenditures for abatement equipment
Supercritical CO ₂ Delivery Device	<ul style="list-style-type: none"> New market for suppliers of innovative equipment 	<ul style="list-style-type: none"> Share shift opportunities for innovative suppliers 	<ul style="list-style-type: none"> Equipment costs which were 20-33% of those anticipated for abatement equipment
			<ul style="list-style-type: none"> Lower coatings costs from reduced solvents
			<ul style="list-style-type: none"> Improved working conditions
			<ul style="list-style-type: none"> Improved surface appearance
Waterborne Coatings		<ul style="list-style-type: none"> Share shift opportunities for innovative suppliers 	

Competitive Effects of Architectural Coatings Regulations
on the Industry and Its Suppliers

Method	Architectural Coating Suppliers	Architectural Coating Users
Waterborne Paint Systems	1 share shift opportunity for innovative suppliers	1 Comparable cost to solvent-borne
		1 Reduced odor and fumes from painting

Direct Effects on Product

OEM Markets for Innovative Products

Regulations on OEM coatings processes threatened to force substantial costs on manufacturers. Facility managers faced a choice between high costs for control equipment or adoption of innovative but developmental coatings which initially were not thought to provide the performance of previously used coatings. In response, suppliers undertook research efforts attempting to develop products which provided the required performance and could limit the need for control equipment. In a few large market segments which enjoyed competition from large technically sophisticated suppliers, dramatic changes in product technology occurred. However these investments were limited by traditional constraints on industrial innovations. Smaller suppliers simply did not possess the resources necessary for extensive technical efforts. The fragmented nature of the OEM coatings market, further worked against substantial research investment. Smaller market segments, although potentially large emitters of VOCs did not attract large investments because the potential rewards for the innovative suppliers were smaller. The ability of manufacturers to meet regulation with innovation was dependent on the structure of their own industry as well as that of their suppliers. The contrast between large concentrated industries and smaller fragmented markets can be seen in the following discussion of the automobile and the wood furniture markets as each of these industries faced increasing regulation on their releases of VOCs.

The market for transportation (automobile, truck, and other vehicle) coatings was the largest segment of the OEM market. In the U.S. alone, the 1990 sales for this segment were more than \$1.2 billion. In

addition, the market for autobody refinish coatings (categorized as special purpose because the product was not “original equipment”) had sales of more than \$1.2 billion. These markets were supplied by large integrated Firms such as Dupont, BASF, and ICI. All of the major suppliers served this market as part of diversified chemical operations.

Painting an automobile was a complex process involving the application of several layers of coatings with baking processes in between. Each of these layers utilized differing formulations and application methods. As a result, concerns with solvent emissions varied depending on the step of the process. For example, very small amounts of VOCs were released in the application of the protective electrodeposition coat (E-coat) which was performed using a dip process in a water-borne coating.⁴¹

The application of the E-coat was followed by a primer surfacer and then a color coat. A great deal of attention had been focused on options for reducing the solvent content of the color coat. In the 1960s, two types of systems were used for color coats in the U.S. GM applied a monocoat lacquer while Ford and Chrysler employed low solids enamel systems.⁴² In response to a 1972 amendment to California’s Rule 66, GM needed to change to a water-borne enamel system at its South Gate, California and Van Nuys, California assembly plants.

Unrelated to environmental concerns, the automobile industry faced a new challenge in the late 1970s. At that time, European imports were being marketed which had a clearly superior appearance than U.S. manufactured vehicles. European firms, notably BMW and Mercedes Benz, had introduced a new technology to their operations. Instead of searching for a single monocoat material which offered color, metallic, gloss, and protective properties, they used a two stage basecoat/clearcoat method. The basecoat could be formulated to control the metal components of the coating as well as incorporate high pigment loadings. The clearcoat could be engineered for gloss, “distinctness of image,” and durability.

41. PPG Industries, William V. Wamick - Director Coatings and Resins Manufacturing, Interview, Pittsburgh, PA, February 25, 1993

42. Jamrog, Robert, “Automotive Water-Borne Coatings: Clean Air Legislation is Pushing Automakers Toward Water-Borne Basecoats,” *Products Finishing*, October, 1993

The U.S. automobile industry shifted to basecoat/clearcoat technologies during the 1970s and early 1980s. However, regulations were such that any new plant would need to reduce emissions to the level achieved by those GM plants using water-borne enamels in California. GM, anticipating opening three new plants in 1980 and viewing the requirements based on water-borne enamels as inappropriate for plants where the two step basecoat/clearcoat was going to be applied, sued the EPA claiming the agency had built its regulation around obsolete technology. Further, GM positioned the discussion as an important competitive issue. They argued that if the U.S. auto makers were forced by the regulations to use the poorly performing enamels, they would surely lose additional market share to European and Japanese imports.

A compromise was reached in which manufacturers were granted innovative technology waivers to the New Source Performance Standards. The innovative technologies were based on achieving lower emissions while employing basecoat/clearcoat. Similarly, existing facilities were allowed more time to bring down emissions following the release of a Federal Register Notice from the Reagan Administration which encouraged extending the compliance deadlines.⁴³

After some disappointing attempts at using water-borne basecoats, the U.S. manufacturers began to adopt systems which were solvent-borne but higher in solids content. Increasingly strict regulations pushed the manufacturers to reduce solvent content to the point where performance trade-offs were again being made. With high solids, gloss and distinction of image were compromised.⁴⁴

European manufacturers watched U.S. developments closely. They anticipated growing regulations in their own markets (as occurred in Germany, Sweden, and the U.K.) and were anxious to avoid the performance trade-offs required by high solids basecoat/clearcoat systems. This led European automobile manufacturers and their coatings suppliers to work together to find an acceptable waterborne technology

43. U.S. Environmental Protection Agency, David Salman - Industrial Engineer, Interview October 5, 1993

44. Jamrog, Robert, "Automotive Water-Borne Coatings: Clean Air Legislation is Pushing Automakers Toward Water-borne Basecoats, " Products Finishing, October, 1993

which would match the appearance of low-solids solvent-borne basecoat/clearcoat systems, In 1986, Volvo began using a water-borne basecoat developed by ICI in its Gothenburg, Sweden facility. The coating used an aqueous microgel technology supplied by ICI which the company had begun to research in the late 1970s.⁴⁵

Water-borne basecoats of this type were quickly adopted at new installations by other manufacturers. At the same time, BASF was developing a different technology which proved successful for water-borne basecoats. By 1993, nine plants in Germany and two in other parts of Europe were using water-borne basecoat systems.

BASF and ICI began to transfer their technologies to the U.S. later in the decade. Although Imnont had researched water-borne systems prior to its acquisition by BASF, much of the technology used in the systems sold in North America relied on developments made in the European operations. DuPont and PPG, the only other two U.S. suppliers of basecoats licensed the ICI technology.

By 1993, industry leaders estimated that 20% of the world's automobile plants were using water-borne basecoats⁴⁶ In North America, four plants were using systems based on the ICI technology, two were using BASF, and one used multiple suppliers. Further, BASF was planning to provide water-borne basecoats to the \$1.3 billion U.S. autobody refinish market by 1993.⁴⁷ ICI, which had not previously supplied refinish paints in the U.S., had announced a similar entry into this market.⁴⁸

U.S. automobile manufacturers were quick to point to achievements in emissions reductions which occurred between the 1970s and the 1990s. In that time, average releases of VOCs per vehicle were

45. IDAC, Dr. J. Pearson, Managing Director, IDAC UK, Telephone Interview, August 23, 1993

46 "Environment Drives Automotives: Waterborne High-Solid Paints Spread," Chemicalweek. October 13, 1993

47 "Bodyshops Go Green," Polymers Paint Colour Journal

48. Wall, C., "Environmental Breakthrough for Refinish Paints," Polymers Paint Colour Journal

estimated to have been reduced from 15.5 pounds to 3.5 pounds, an 80% reduction.⁴⁹ They were just as quick to point out that these improvements were achieved at high cost in technology development, capital equipment, and possibly reduced sales resulting from lowered product attractiveness. Requirements outlined in the 1990 Clean Air Act Amendments put additional demands on the industry requiring even greater reductions, particularly in siting new or significantly modified facilities. Potential innovations which were being considered to meet these requirements included further adoption of water-borne base coat systems as well as utilization of powder coating systems for primer and clear coat operations.⁵⁰ If successful, these modifications were anticipated to bring the total release per vehicle to 1.5 pounds.

In contrast to the automobile companies, wood furniture manufacturers were often small firms with thin profit margins. The coatings market for this industry was much smaller with 1990 U.S. sales of \$340 million. Although this segment was fairly highly concentrated with four primary suppliers, its small size resulted in relatively low revenue for any one manufacturer. In southern California, rule 1136 required 93% reductions of VOC emissions from coating operations in this industry by 1996. Interim deadlines in 1989, 1990, and 1994 required substantial reductions. As the first deadlines approached, manufacturers were faced with a dilemma; few could afford control equipment and existing low solvent technologies were felt to be of substantially lower quality than higher solvent coatings. A study by the General Accounting Office in 1991 estimated that between 1 and 3% of these firms chose to relocate in Mexico in the years between 1988 and 1990.⁵¹ In addition, as many as 11% of other affected wood furniture manufacturers may have moved to other parts of the U.S. While many factors affected the

49. American Automobile Manufacturers Association, Interview, Bill King, May 27, 1993

50. United States Council for Automotive Research, "Plant Emissions Latest Big Three Research Target," Press Release, February 18, 1993

51. United States General Accounting Office, report on wood furniture manufacturer relocation to Mexico, April 24, 1991, B-243621, GAO/NSIAD-91-191

decision of these firms to move, 78% cited stringent air pollution control requirements as a significant factor in their decision (83% cited the high costs for workers' compensation insurance and wages).⁵²

Representatives of the South Coast Air Quality Management District reported in 1990 that the stringency of the regulations had been intended to prod furniture manufacturers into developing new low solvent coatings.⁵³ These regulators may not have considered that even the largest suppliers achieved revenues from this segment of less than \$100 million.

The requirements in southern California did highlight increasing concerns for wood furniture coatings. However, although supplying firms began intensive research efforts, the development of compliant coatings which had acceptable performance took several years and the process required cooperation with suppliers as well as customers (the wood furniture manufacturing industry).⁵⁴ By the early 1990s, significant improvements in the performance of water-borne coatings had been made in this segment and few companies were then moving operations.⁵⁵ However, for the estimated 1,000 - 7,000 workers who were displaced, the innovations came too late.⁵⁶

Development of No-Solvent Coatings

Achieving higher transfer efficiencies and lowering solvent content was not merely an environmental issue. Anything less than 100% transfer efficiency implies some level of wasted material. Overspray, the paint which is not deposited on the product, must be collected and disposed. Solvent is included in the paint merely to be released later. Obviously, elimination of solvent or improved transfer efficiencies could reduce cost. This fact led manufacturers to explore the potential of radiation cured and powder

52. United States General Accounting Office, report on wood furniture manufacturer relocation to Mexico, April 24, 1991, B-243621, GAO/NSIAD-91-191

53. Kraul, Chris, "A Warmer Climate for Furniture Makers," The Los Angeles Times, May 14, 1990

54. Lilly Industries, Inc., 1991 Annual Report, "Research and Development: Our Foundation for the Future"

55. Lilly Industries Inc., Bob Bailey - Vice President of Marketing, Telephone Interview, February 11, 1993

56. United States General Accounting Office, report on wood furniture manufacturer relocation to Mexico, April 24, 1991, B-243621, GAO/NSIAD-91-191

coatings. These materials offered the possibility of solvent free coating application with almost 100% transfer efficiency.

Radiation cured coatings used low molecular weight monomers which reacted to form a film when exposed to UV light or electron beams. Powder coatings were typically applied through an electrostatic deposition process and then exposed to heat. When the coating reached its melting point a thin resilient film was formed. The prospect of increasing environmental regulations limiting VOC emissions spurred growing interest in both radiation cured and powder coatings in the early 1990s. Expansion of these markets was anticipated by most paint market analysts.⁵⁷ In 1990, however, radiation cured coatings and powder coatings each constituted only about 2% of the total paint market.⁵⁸

The primary limitation on radiation and powder coatings was the difficulty in achieving acceptable finishes when applying the material to non-uniform surfaces. Radiation coatings could only be applied to flat surfaces so applications were limited to such areas as flat wood paneling and printing applications. Using electrostatic processes, powder coatings could be applied to more varied surfaces. However, appearance problems were still being overcome in the early 1990s. Although increasing advances were expanding the markets for these coatings into such areas as automotive finishes and metal furniture paints, the largest markets for powder coatings remained in areas of simple geometries. In 1992, appliance coatings accounted for 21 % of powder coating markets and coatings for simple automotive parts (such as underbodies and wheels) made up 15 % .⁵⁹

OEM Markets for Innovative Equipment

Some regulations in California addressed transfer efficiency as well as solvent content of the coating. Transfer efficiency was a measure of the ratio of the amount of coating deposited on the substrate to the

57 U. S. Department of Commerce, U. S. Industrial Outlook, 1993, "Paints and Coatings," p. 11-8 through 11-9

58. U. S. Depart of Commerce, Current Industrial Reports, Paints and Allied Products, 1990

59. Powder Coatings Institute, "Powder Coatings - Markets and Applications," Gregory J. Bocchi, Executive Director, 1993

total amount of coating used in the painting process. Using a low VOC paint in a process with poor transfer efficiency would provide little benefit overall in reducing VOC emissions. As a result, in those areas where manufacturers had options in application devices, tables were developed which applied a transfer efficiency rating to each device. Higher VOC content was permitted with higher transfer efficiency.⁶⁰ Rules 1136 and 1151, promulgated by the South Coast Air Quality Management Board (SCAQMB), attempted to achieve a minimum of 65% transfer efficiency. The rules stipulated that if spray guns were used they had to have a maximum nozzle pressure of 10 psig (pounds per square inch, gauge). Spray equipment which complied with this rule was termed High Volume/Low Pressure, HVLP, and used high speed turbines rather than compressed air to atomize the coating.

Industry challenged the equipment specifications of rules 1136 and 1151. Manufacturers claimed that many factors affected transfer efficiency and that spray equipment was potentially less important than other issues.⁶¹ Further, they suggested that use of HVLP equipment would increase spray time and thus increase costs of manufacturing operations.

A comprehensive study of spray painting systems used in wood furniture manufacturing concurred with manufacturers' worries about the equipment. In this study, four types of coatings were used in six types of spray equipment. An expert and a novice painter coated doors and window frames to determine the influence of different factors in reducing VOC emissions. The researchers concluded that using water-borne coatings and having painters become more proficient were the most effective methods of reducing VOC emissions. Surprisingly, in about half of the cases, using HVLP equipment resulted in lower transfer efficiency than using conventional airspray systems (and required more time). Air assisted HVLP equipment provided a desirable combination of reduced spray time and lowered VOC emissions.⁶²

60. U.S. Environmental Protection Agency, James Berry - Section Chief and David Salman - Industrial Engineer, Interview January 19, 1993

61. Schrantz, Joe and Bailey, Jane, "Under the Gun to Conform in California," Industrial Finishing, June 1989

62. Snowden-Swan, Lesley, "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Battelle Pacific Northwest Laboratories, Pacific Northwest Pollution Prevention Research Center, November, 1992

Improving transfer efficiency provides a clear example where better environmental performance could be coupled with attractive economics. However, the study discussed above suggested that the methods required by SCAQMB were not necessarily the best means of achieving these goals. These results suggest that regulators must be cautious in being overly prescriptive in identifying means of achieving environmental improvement even when those means should provide economic advantages. Subtle differences in facilities, in products, and - as in this case - operator skill can substantially influence anticipated outcomes.

One of the most innovative approaches to reducing VOC emissions from paint application was the Unicarb system developed by Union Carbide in 1989. Rather than look to other types of liquids to replace existing solvents, the company developed a system which took advantage of the solvent-like properties of carbon dioxide under high pressure. Termed “supercritical,” the highly pressured carbon dioxide replaced the “cutting solvent” which was used to carry the resin and pigment through the application device. It volatilized prior to deposition on the product, similar to a cutting solvent. Coalescing solvents which remained in the system ensured a smooth layer and uniform film thickness.⁶³

The Unicarb system was initially developed in response to environmental concerns, but the earliest applications of the technology were in locations where VOC regulations were not particularly strict.⁶⁴ The company suggested that additional benefits spurred manufacturers to switch to the Unicarb system. Some of the advantages claimed by the company included:⁶⁵

- * Improvement in working conditions because carbon dioxide is odorless
- * Improvement in safety because carbon dioxide is not flammable
- * Superior coating performance through the use of higher molecular weight resins

63. Union Carbide Chemicals and Plastics Company Inc., “Unicarb System for Spray Coating: A major Advance in VOC-Reduction Technology,” Company Promotional Literature

64. Union Carbide Chemicals and Plastics Company Inc., Dr. Dave Buzby - Development Scientist, Telephone Interview, March 8, 1993

65. Union Carbide Chemicals and Plastics Company Inc., “Unicarb System for Spray Coating: A Major Advance in VOC-Reduction Technology,” Company Promotional Literature

- * A more uniform surface than other low VOC systems
- * Low capital expenditure compliance option

The company claimed that the cost of removing VOCs using the Unicarb system ranged from one-third to one-fifth that of using carbon absorption or incineration systems.⁶⁶ Union Carbide chose to market neither coatings nor application equipment. Instead, the technology was being licensed to several firms specializing in each of these areas.

Architectural Coatings Markets for Innovative Products

In architectural coatings, the trend toward lower solvent products had continued since the first introduction of water-borne coatings by Glidden in 1948.⁶⁷ Many of the advantages driving this trend were summarized in an industry response to the EPA during negotiations over the adoption of architectural coatings rules in 1993:

“As with all highly competitive markets, reducing product costs and introducing technological innovation are among the chief means by which a company can increase its market share. This fact has been largely responsible for the shift from solvent-borne products -- a shift that has both reduced manufacturers’ cost by reducing the solvent content of products and responded to consumers’ demand for products that have less odor and are easier to clean up.”⁶⁸

However, the same document went on to identify five deficiencies in water-borne paints as compared to solvent-borne systems:

66. “Supercritical CO₂ as a Solvent: Update on Union Carbide’s Process,” Modern Paint and Coatings, June 1990

67. Yerak, Rebecca, “No-smell Coating: New Glidden Paint Safe for Environment,” The Plain Dealer, Cleveland, Ohio, July 21, 1992

68. “Responses: Questions and Issues Raised by State, Environmental, and EPA Members of the AJM Reg-Neg Committee Concerning the Industry Caucus Proposal of January 6, 1993,” Response Submitted to the Full Reg-Neg Committee on February 11, 1993

* Water-borne products were more sensitive to surface conditions

- Water-borne coatings could be more difficult to apply
- Water-borne paints dried quickly but “cured” slowly

*Water-borne paints did not cure at lower temperatures

* Water-borne products generally formed a softer film than solvent-borne coatings

Thus, the message from producers of architectural coatings was in support of regulations which had an accelerating effect on existing market trends. However, flexibility was desired to allow continued production of coatings for applications with requirements closely matched to the characteristics of high solvent coatings. Unfortunately, regulators could never be sure that specific coatings would only be used for the narrow applications for which they were intended. Therefore, regulators tended to demand lower solvent levels in all coatings intended for consumer purchase.

Limitations to Innovation

Clearly, the regulations affecting VOC emissions showed a variety of approaches to innovation. However, in a series of legal challenges (primarily in California) and responses to pending regulation, industry raised some concerns about the ability to innovate within the structure of the regulations. The primary issues which were raised follow:

1 An industry sponsored group in California won a lawsuit against pending architectural coatings regulations making, among other claims, the assertion that the rules would encourage the use of inferior coatings. It was argued that consumers would be forced to use more paint, or repaint more frequently, and therefore, VOC emissions could be exacerbated by the regulations.

1 Again primarily in California, manufacturers complained that tests for measuring transfer efficiency were poorly designed. It was asserted that lower VOC coatings used in application systems with lower transfer efficiency would continue to yield high emissions.

1 In the U.S. none of the regulations rewarded the advantages of thinner coatings. Because thinner coatings required less paint to cover a surface, less VOCs would be released in using a thinner, rather than a thicker coating. Although not addressed in the regulations, the thickness of the coating could significantly affect the amount of paint used and thus the VOC emissions resulting from coating a surface. Automotive coatings, for example, ranged for 2.4 to 3.8 mils (a 58% difference).

1 Some industry groups claimed that focusing regulations only on coatings operations did not allow firms to be in compliance by achieving equivalent reductions in emissions in other areas of operations. At times industry intentions appear to have been more to be provocative than practical. For example, the South Coast Finishers and Fabricators Association (SCFFA) recommended to the South Coast Air Quality Management District that emissions targets set for wood furniture manufacturers could be met more cheaply by adopting car pooling and staggered shifts (so travel would occur at less congested times). It was argued that reducing the emissions from employees' cars would more than achieve the goals set for the coatings

Traditionally, water-borne architectural coatings had been priced at or below the price of solvent-borne systems.⁶⁹ However, manufacturers have reported that raw material costs for totally new paint technology may initially have been 20-30% higher.⁷⁰ The confusion on this issue was not cleared up even after extensive study by the State of California Air Resources Board. In July of 1989, the Technical Review Group of the Architectural Coatings Committee concluded, "the economic impact to consumers from reformulating coatings can be either positive or negative and is difficult to estimate."⁷¹

The primary cost concern to industry had not been the change in raw material prices. In the early 1990s, the cost of developing new formulations was the most important concern for many firms. At a minimum, the development of a new coating required the dedication of two researchers with access to necessary laboratory and pilot production facilities.⁷² Development typically took two to four years with the latter stages requiring long-term performance testing.⁷³ Particularly when changing to water-borne systems, production facilities could be required to be modified to handle new materials in the formulations.⁷⁴ Clearly then, the development of a new coating could reach costs in the hundreds of thousands of dollars.

As has been described, the structure of the architectural coatings industry was very different than that of OEM coatings suppliers. In 1990, the three largest manufacturers accounted for 36.5% of the market. Meanwhile, hundreds of small manufacturers, with little or no development capabilities were producing

69 "Responses: Questions and Issues Raised by State, Environmental, and EPA Members of the AIM Reg-Neg Committee Concerning the Industry Caucus Proposal of January 6, 1993," Response Submitted to the Full Reg-Neg Committee on February 11, 1993

70. Courtaulds Coatings, Stanley Hope - Manufacturing & Environmental Manager, Interview, April 13, 1993 and Glidden Co., Jim Sainsbury - Manager Products Regulation, Interview, February 18, 1993

71. California Air Resources Board Stationary Source Division, "ARB-CAPCOA Suggested Control Measure for Architectural Coating: Technical Support Document," July 1989, p. 22

72. Courtaulds Coatings, Stanley Hope - Manufacturing & Environmental Manager, Interview, April 13, 1993 and Glidden Co., Jim Sainsbury - Manager Products Regulation, Interview, February 18, 1993

73. Glidden Co., Jim Sainsbury - Manager Products Regulation, Interview, February 18, 1993

74. Courtaulds Coatings, James K. Chapman - Vice President Manufacturing & Distribution, Interview, April 13, 1993

small quantities of material. Adopting highly restrictive or technology forcing regulations would likely provide a strategic advantage to the largest firms who could spread the cost of development over the greatest volume. In fact, some of the largest producers had already dedicated large investments to providing paints with reduced VOC emissions.

In 1992 Glidden introduced the first architectural coating to employ no organic solvents at all. Using an innovative resin system developed by Rohm & Haas Chemical Co., the company was able to eliminate even the coalescing solvents which were normally needed to assure a smooth surface finish.⁷⁵ The company highlighted the additional benefits of low odor and ease of clean up, but the primary motivation for its development was the recognized market for environmentally friendly products.⁷⁶ However, by having no VOCs, the product formulation was well beyond the requirements of even the most stringent California regulations. As has been noted earlier, Glidden became part of the ICI paints World Group in 1986. The management of this organization had concluded that long term regulatory trends would reward those companies which developed technical expertise in areas where negative environmental impacts of products could be reduced.⁷⁷

When Glidden set out to develop a solvent free product, the company decided that to be successful, the paint would have to achieve the desired environmental benefits with no reduction in performance. A particular difficulty was to assure acceptable hardness of the coating (this was important for trim areas such as windows and doorways). The solvent which was part of existing water-borne coatings was used as a coalescing agent promoting a harder paint surface. Achieving the required hardness in a solvent free coating required using a 100% acrylic resin system. This resulted in raw material costs substantially higher than those for many other Glidden products. Pricing was comparably higher. One source

75. Yerak, Rebecca, "No-smell Coating: New Glidden Paint Safe for Environment," The Plain Dealer, Cleveland, Ohio, July 21, 1992

76. The Glidden Company, "Glidden to Remove Petroleum-Based Solvents From Architectural Paints: First Solvent-Free Traditional Paint to Arrive in June," Company Press Release, May 28, 1992

77. Glidden Co., David Maurer - Product Planning Manager, Telephone Interview, August 27, 1993

reported pricing 50% higher for the solvent free paints than for traditional latex brands.⁷⁸ Within Glidden's existing channels of distribution, this price difference appeared dramatic. However, the company pointed out that if a comparison was made to other paints with high acrylic content the pricing was more similar.⁷⁹ Most of these were sold through paint stores where customers were more likely to make purchase decisions based on subtle characteristics of performance. Glidden, on the other hand, had marketed its coatings through large retailers and home improvement stores where price was more important.

Glidden marketed the acrylic resin water-based product in the U.S and Canada and anticipated entry into Australia. In the U.K., ICI used a different formulation for its VOC-free paint. British customers routinely used different paints for trim than they used for walls. Trim paints were formulated from alkyd resins which provided a very hard glossy surface. The paints used on the larger wall areas (flat paints) could be softer and were mostly latex type. Without the need for high hardness, ICI had developed a different type of solvent free paint which did not require coalescing solvents. The differing approaches demonstrates that in some cases, even with similar environmental requirements, different market characteristics lead to different innovations.

Indirect Effects on Pollution Control Industries

Regulations aimed at reducing VOC emission from coatings focused on achieving reductions equivalent to employing control devices with high levels of efficiency. Although this could require a significant capital expenditure, some manufacturers chose to modify production facilities rather than substitute new coatings. In coil coating lines (products used for metal building siding and other applications), manufacturers used medium and high solids coatings with incinerators on the ovens to burn the solvents⁸⁰

78. Yerak, Rebecca, "No-smell Coating: New Glidden Paint Safe for Environment," The Plain Dealer, Cleveland, Ohio, July 21, 1992

79. Glidden Co., David Maurer - Product Planning Manager, Telephone Interview, August 27, 1993

80. Lilly Industries Inc., Bob Bailey - Vice President of Marketing. Telephone Interview, February 11, 1993

CONCLUSIONS

Innovation is an important part of improving the quality of the environment while maintaining a strong industrial base. As demonstrated by paint suppliers, firms will dedicate large resources to these innovations when the regulations are structured to allow new approaches to compliance and the management of the firm feels the market being created is sufficiently large to provide returns on the resources dedicated to achieving new developments.

1) If regulations are likely to be met by supplier innovations, the size and resource availability of those firms will significantly affect their response to new requirements on their products.

The actions taken by architectural coatings manufacturers demonstrated the effect of varying resources on the response of industry to new regulations. For firms affected by regulation, the availability of resources may not be equivalent. Large firms may be able to quickly respond to regulations with innovative solutions which satisfy all product performance needs including regulatory compliance. At the same time, smaller firms, unable to match the development budgets of their larger rivals, may have no option but to resist and delay the regulations as much as possible.

This conflict could be seen in the early response to regulations on architectural coatings. In 1993 there were hundreds of manufacturers of architectural coatings. The top five supplied more than 45% of the market and each had sales of more than \$180 million, but the typical architectural coatings firm had revenues of less than \$5 million. In 1993, the regulatory negotiation was on-going concerning a national rule for VOC reduction in architectural coatings. Regulations which demanded rapid compliance or significant changes in product formulations would be expected to provide competitive advantages to the larger manufacturers with the resources to devote to research and development of new coatings. Smaller firms would not be able to keep up. As was already evident, as regulations began to take effect in California, large firms had begun to innovate with lower VOC formulations - even achieving a no VOC system - while many smaller firms had resisted regulation through litigation. Without some form of intervention, these firms could have become the losers in the trade-off between achieving regional

environmental goals and maintaining the existing characteristics of the industry's competitiveness. On the other hand, protecting small firms by adopting less rigorous standards or allowing longer implementation periods would have required accepting reduced environmental benefits.

2) Supplying firms will only respond to regulations with innovations in those markets which are large enough to justify their dedication of research resources.

The response of the paint industry in different OEM markets provides insights to the importance of the size of the market for innovative approaches to compliance. OEM manufacturers made significant progress in reducing the level of VOC emissions resulting from their coating operations between 1986 and 1991. The 15 % reduction in these emissions which resulted was achieved through the use of a variety of methods including material substitution, equipment changes, and adoption of control devices. In each of these areas, the products and equipment needed to achieve lowered emissions were developed by supplying industries to the ultimate manufacturer. For the upstream industries, the promulgation of regulations either created or significantly altered the industry's market. In every case, the upstream innovations provided additional options for lowering VOC emissions in coating operations. As a result, many manufacturers were able to reach (and at times exceed) compliance at costs significantly lower than would have been possible had regulations exclusively demanded the use of pollution control equipment.

As it became clear that automotive manufacturers would progressively move toward water-borne coatings, the large size of this market provided satisfactory justification for suppliers to research and improve these products. On the other hand, when only California regulated wood furniture manufacturers, the small size of the market and the technical difficulties encountered delayed manufacturers from achieving compliant coatings. Lacking innovative, lower cost solutions, some manufacturers found it impossible to compete with unregulated manufacturers and moved operations. Even as national regulations were being developed in 1993, it was unclear whether manufacturers would be able to supply all wood furniture markets with water-borne coatings which performed comparably to solvent-borne systems.

3) Those companies which target long term trends will be best positioned to benefit when regulations are adopted.

When U.S. automobile manufacturers were first regulated for VOC emissions, they responded by adopting the best then available option, high solids coatings. At that time, no suitable water-borne base coat was available. However, ICI had conducted more than a decade of research in hopes of developing a water-borne coating which could match the performance characteristics of solvent-borne base coats. Although ICI's customers were not likely to be regulated until the mid to late 1990s the company was able to achieve benefits from their research by licensing U.S. suppliers to use their technology. Additionally, the applicability of the technology to the larger automobile refinishing market, facilitated the company's entry into a market in the U.S. where it had previously not participated.

The characteristics of innovations in the paint industry have implications to any other regulated area. Here, as in many other areas, the innovations have not occurred within the regulated industry itself. Instead, new approaches were developed by suppliers at least one step up the value chain. In the case of new resin systems, the new developments were several steps upstream. These upstream industries must choose how to dedicate scarce resources. They will dedicate these resources to methods of lower cost environmental compliance when the regulations are structured to allow creative methods, the market for innovations is large relative to the required development investment, firms possess the needed resources, and the decision makers in the regulated area are receptive to new approaches of achieving compliance.

TABLE 1
World Export Share Development
Paints and Varnish

Country	1980	1985	1990
West Germany	23.1%	23.3%	24.6%
United Kingdom	11.9%	10.5%	10.1%
Netherlands	11.1%	10.6%	10.7%
United States	9.1%	9.3%	9.2%
France	7.5%	7.4%	7.1%
Belgium	4.9%	5.3%	5.5%
Japan	4.1%	6.2%	4.3%
Italy	4.6%	-	5.0%
Finland	2.1%	1.5%	1.6%
Switzerland	1.7%	2.0%	2.2%

Source: UN Trade Statistics Yearbook 1990

TABLE 2
World Import Share Development
Paints and Varnishes

Country	1980	1985	1990
West German	7.8%	7.2%	9.3%
United Kingdom	4.1%	5.1%	6.0%
Netherlands	6.0%	6	5.8%
United States	1.1%	2.7%	3.0%
France	9.6%	8.4%	9.5%
Belgium	5.8%	4.9%	6.2%
Japan	2.1%	2.0%	1.7%
Italy	4.7%	4.8%	5.4%
Finland	1.4%	1.2%	1.4%
Switzerland	3.3%	3.1%	3.1%

Source UN Trade Statistic Yearbook, 1990

TABLE 3
Trade Balance Development
Paints and Varnishes
(thousands)

Country	1980	1985	1990
West Germany	\$347,768	\$353,753	\$802,815
United Kingdom	\$176,553	\$120,377	\$229,077
Netherlands	\$127,169	\$106,361	\$267,967
United States	\$173,315	\$151,23	\$317,536
France	(\$14,668)	(\$5,260)	(\$65,685)
Belgium	\$283	\$16,115	(\$543)
Japan	\$49,100	\$90,492	\$154,060
Italy	\$11,881	\$2,965	\$10,323
Finland	\$17,97	\$9,029	\$16,268
Switzerland	(\$25,412)	(\$17,663)	(\$25,609)

Source: UN Trade Statistic Yearbook 1990

TABLE 4
World Export Share Development
All Pigments and Paints

	1980	1985	1990
West Germany	25.6%	24.7%	24.0%
United Kingdom	13.2%	11.5%	10.9%
Netherlands	9.4%	9.0	8.0
United States	7.0	7.3%	10.1%
France	8.5%	8.9%	7.3%
Belgium	6.6%	6.5%	7.0%
Japan	4.6%	6.8%	6.0%
Italy	4.6%	4.4%	4.1%
Finland	2.6%	2.7%	2.4%
Switzerland	2.7	3	2.1%

Source: UN Trade Statistic Yearbook 1990

TABLE 5
World Import Share Development
All Pigments and Paints

Countr	1980	1985	1990
West Germany	8.7%	8.3%	9.7%
United Kingdom	3.9%	5.0%	6.0%
Netherlands	5.7%	5.5%	5.4%
United States	2.5%	6.7	5.7%
France	9.4	7.9%	9.2
Belgium	5.1%	4.2%	5.2%
Japan	2.4	3.1%	2.8%
Italy	5.3%	5.1%	6.1%
Finland	1.2%	1.0	1.1%
Switzerland	3.5%	3.2%	3.1

Source: UN Trade Statistic Yearbook, 1990

TABLE 6
Trade Balance Development
All Pigments and Paints
(thousands)

Country	1980	1985	1990
West Germany	\$820,153	\$775,732	\$1,702,246
United Kingdom	\$446,536	\$308,755	\$596,105
Netherland	\$196,671	\$168,586	\$302,945
United States	\$215,683	\$38,210	\$572,1
France	\$ 6 ,	\$60,53	(\$156,331
Belgium	\$93,683	\$113,392	\$244,462
Japan	\$112,336	\$178,9	\$388,461
Italy	(\$5,267)	623,449)	(\$190,595
Finland	\$70,195	\$81,693	\$150,749
Switzerland	(\$19,309)	(\$4715	\$83,305

Source: UN Trade Statistic Yearbook, 1990

TABLE 7
U.S. Total Quantity and Value of Shipments of Paint and Allied Products

Category	1988 Value(million)	1989 Value (million)	1990 Value (million)
Architectural Coatings	\$ 4 4 2.6	4,525.3	\$4,913.6
Product Coating OEM	\$4,104.5	\$4,220.1	\$4,033.3
Special Purpose Coating	\$2251.8	\$2,493.5	\$2,781.5
Miscellaneous Allied Products	\$1052.3	\$1092.7	\$1,170.7
Total	\$11,835.4	\$12,331.6	\$12,898.4

Source. U.S.. Department of Commerce, Current Industrial Reports, Paint and Allied Products, 1991

TABLE 8
European Paints and Coatings Production
(millions)

Country	1985	1990
West Germany	\$3,583	\$4,312
France	\$2,111	\$2,585
United Kingdom	\$2,028	\$2,111
Italy	\$1,585	\$1,993
Netherlands	\$735	\$898
Spain	\$640	\$751
Belgium	\$439	\$544
Sweden	\$465	\$504
Switzerland	\$345	\$439
Denmark	\$379	\$417

Source: Chemicalweek, October 31, 1990

TABLE 9
Leading U.S. Architectural Coatings Manufacturers
(millions)

Company	1989 U.S. Sales
Sherwin-Williams	\$750
Glidden	\$620
Benjamin Moore	\$350
PPG Industries	\$303
Desoto	\$180
Kelly Moore	\$175
Valspar	\$170
Grow Group	\$160
Prair & Lambert	\$140
Porter Paint	\$105

Source: Chemicalweek October 31, 1990

TABLE 10
Volatile Organic Compound Emissions of Selected Industrialized Countries

Country	GDP (\$ billion)	Population (million)	VOC (millionton)	VOC/GDP lb/SK	VOC per capita lb/capita
U.S.A	5,673	252.5	16.9	6.57	148
Austria	164	7.8	0.5	6.72	141
Sweden	230	8.5	0.4	4.22	114
France	1,032	57	2.77	5.92	107
U.K.	913	57.6	2.7	6.52	103
West Germany	1,234	63.7	2.6	4.64	90
Netherlands	249.1	15	0.5	4.16	69
Italy	969	57.8	1.53	3.48	58

Sources: 'Handbook of International Economic Statistics, 1992; U.S. EPA 'National Air Pollution Emission Estimates, 1900-1991, October 1992,' U.S. Department of Commerce. 'Western Europe Office, Country Profiles; VOC Newsletter, 8/92, Projectbureau KWS 2000. The Hague The Netherlands: Statistics Sweden 'The Swedish Environment, 1991; Centre Interprofessionnel Technique D'Etudes de la Pollution Atmosphérique (CITEPA). 'Emissions De COV; Reglementations Française Et Européenne, Techniques De Réduction' 1992; U.K. Department Environment, Personal Communication from Norman Horrocks, 'Reducing Emission of VOCs: A U.K. Strategy.'; Federal Ministry for the Environment, "Environmental Protection in Germany," June 1992; Project Group Hydrocarbons 2000. 'Control Strategy for Emissions of Volatile organic Compounds Project KWS 2000. Department of Air Pollution, Ministerio Del Ambiente, Personal Communication, M. Gusparini M. Rizz

TABLE 11
Comparison of Regulations: Automotive Manufacturing

Allowable emissions per vehicle (assuming 110 square meters of surface area per vehicle and using performance results reported by American Automobile Manufacturers Association for U.S. values)

	United States	Germany	United Kingdom
Emissions (grams)	1,590	3,850	6,600
Emissions (pounds)	3.5	8.5	14.5

TABLE 12
Comparison of Regulations: Wood Furniture Manufacturing

Allowable solvent content in coating materials

	Southern California	United Kingdom
Clear Topcoats	275 g/l	400-435 g
Pigmented Coatings	275 g/l	525 g/l